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ELECTRONIC CONTROL AND GUIDANCE DIVISION

REPORT ON

FEASIBILITY OF TESTING THE AAFCS
VIGILANTE FOR CBR EFFECTS (U)

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Third Report on Ordnance Project No TW-300

(D A Project No 501-04-087)

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SEPTEMBER 1959



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FEASIBILITY OF TESTING THE AAFCS

VIGILANTE FOR CBR EFFECTS (U)

Third Report on Ordnance Project No. TW-300

Dates of Study: 6 March to 6 August 1959

ABSTRACT (C)

↓ This report presents a discussion of the possible effects of chemical, biological and radiological warfare on the equipment comprising the Vigilante fire control system. The feasibility of testing the system under actual CBR conditions is discussed and some precautions which should be taken to make the system less vulnerable to CBR attack are suggested. A test of the system under actual CBR conditions at this time appears to be impractical, considering the extreme difficulty of decontamination and the probability that little new information would be gained. However, it is recommended that the situation be reviewed in six months to a year.

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1. This report contains information of a confidential nature and its contents in any manner to an unauthorized person is prohibited by law.

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CONTENTS (U)

	<u>PAGE</u>
INTRODUCTION	3
DESCRIPTION OF MATERIEL	4
DISCUSSION	4
Chemical Warfare	4
Biological Warfare	7
Radiological Warfare	8
Summary	11
CONCLUSIONS	12
RECOMMENDATIONS	12
REFERENCES	14
APPENDIX A: DISTRIBUTION	A-1

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1. (C) INTRODUCTION

The tools of modern warfare include some weapons which have never been used and some which have been used only to a limited extent. Some of the potentially most powerful of these weapons are the CBR (i.e., chemical, biological and radiological warfare) agents. Many of these agents are new, but some are as old as man.

The use of chemicals in warfare has been practiced since the beginning of warfare itself. The use of fire and smoke was an early form of chemical warfare. During the First World War chemical gases were used for the first time in large quantities to produce casualties. The Second World War found only one or two isolated cases of chemical casualty agents being used; they were not more widely used chiefly because of fear of reprisal in kind against largely unprotected civilian populations. But incendiary bombs were frequently used on civilian areas.

Biological warfare has never been practiced formally as such, although in the Middle Ages besiegers of cities occasionally dropped plague-infested corpses over city walls. Military biologists have now isolated many disease germs and are working on ways to disseminate these effectively.

Radiological warfare agents were first suggested as practical after the atomic blasts of 1945. They have never been used in combat situations, and their manufacture requires facilities now being used for the production of atomic explosive devices.

The VIGILANTE is a modern antiaircraft weapons system. It is possible that in any future war it would be subjected to an enemy CBR or atomic-device environment. A question has arisen as to what effects such an environment would have on the VIGILANTE and whether it would still be operable after a CBR attack.

Preliminary design specifications for VIGILANTE state that "maximum practicable protection will be provided the equipment . . . from CBR and atomic devices." The information contained in this report was compiled and will be discussed to illustrate in general the CBR- and atomic-device-created environment to which the VIGILANTE system might be exposed, and the effects of this environment on the equipment. Conclusions will be drawn to isolate the most critical factors of CBR and atomic-device attack. Against these factors, certain features of any modern antiaircraft weapons system might be analysed with fruitful results.

The objective of this report, therefore, is to determine the possible effects of a CBR atmosphere on the VIGILANTE fire control system, to determine the feasibility of testing the fire control system under actual CBR warfare conditions, and to suggest any precautions which might be taken to make the system less vulnerable to CBR attacks.

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The discussion will be conducted on four major topics: chemical warfare and its effects; biological warfare and its effects; radiological warfare and its effects; and atomic devices and their effects. The last two topics will be considered together since radiological warfare, for the present, is most likely to be the product of atomic devices.

Since personnel are generally far more vulnerable to CBR attack than equipment, most of the available literature deals with the effects of CBR warfare on personnel. However, it is believed that enough pertinent information has been reviewed to allow a determination of what the effects of a CBR attack on the VIGILANTE might be, and to enable a decision to be made on the feasibility of testing the system under actual CBR conditions.

2. (C) DESCRIPTION OF MATERIEL

VIGILANTE is a modern antiaircraft weapons system. It consists of an analogue computer, radar range finder, optical tracker, and a set of guns capable of firing in bursts at the rate of about 3000 rounds per minute. The system is to be operated by one man. The operator's compartment will be protected with an M2-A1 collective protective filter. Either of two models of the system will be highly mobile. One model will be towed, the other self-propelled. For a more complete description of the system see References 2 and 3.

3. (C) DISCUSSION

3.1 Chemical Warfare

Chemical warfare consists of the use of chemicals for strategic and tactical purposes in combat situations. The chemical agents used may be divided into five basic groups according to their tactical use in the field. These five groups are as follows:

- a. Casualty agents.
- b. Screening smokes.
- c. Signaling smokes.
- d. Incendiary agents.
- e. Training and riot-control gases.

These agents may be introduced in either solid, liquid, or gaseous state depending on the temperature and pressure at which they are employed. They are classed as persistent or nonpersistent, depending on the length of time they remain in an area.

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3.1.1 The Casualty Agents. Commonly known as "war gases," the casualty agents primarily act on personnel. There are four classifications: nerve gases, blister agents, choking agents, and blood poisons.

The nerve gases, "G-agents," are more lethal in lower concentration than any other war gas. Without protection, a man may die within 15 seconds of initial attack. "GB" is the standard agent. It is usually introduced as a vapor, and is nonpersistent. The "G" type gases are noncorrosive and would be harmless to equipment during the time they are in contact.

The common blister agents are the following:

- a. "V" agents.
- b. "H," Levinstein mustard.
- c. "HD," distilled mustard.
- d. "HN," nitrogen mustards.
- e. "HT," toxic agent plus mustard (toxic agent may be arsenic compound).
- f. "L," Lewisite, an arsenic compound.

"H" or "V" agents are most likely to be used. They are disseminated in liquid form or as an aerosol spray. Evaporation will keep the agents in the area for several days. All the other blister agents are either unstable at ordinary temperatures or in the presence of water, or are relatively ineffective against personnel. "H" is absorbed by rubber and will penetrate leather and textile fabrics without harmful effects to these materials. There are apparently no harmful effects to materials from any of the common blister agents.

The choking agents cause the formation of liquid in the lungs and respiratory tract, and produce suffocation. The common choking agents are as follows:

- a. "CG," phosgene, a vapor at ordinary temperatures. When moisture is present it forms hydrochloric acid.
- b. "PS," chloropicrin, a liquid at ordinary temperatures.
- c. "CL," chlorine, a gas at ordinary temperatures.

"CG" is a standard choking agent. It would be corrosive in the presence of water because of the hydrochloric acid formed. In the absence of water it is noncorrosive. "PS" will tarnish unprotected steel. "CL" will corrode metals when wet but is harmless when dry. Metals not protected by painting or other means from the acid might be harmed as the result of a concentrated "CG" or "CL" attack.

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The blood poisons are cyanide compounds. They are:

- a. "CK," cyanogen chloride.
- b. "AD," hydrocyanic acid, a weak, very volatile acid.

"CK" is corrosive when wet. "AD" is too volatile to be used in almost any situation. The blood poisons are classed as substitute standards for the nerve gases, usable under certain conditions because of their heavier-than-air characteristics.

3.1.2 Screening Smokes. These smokes are used as cover during strategic movements. They are:

- a. "WP," white phosphorus. This is used if secondary personnel casualty effects and limited incendiary effects to readily combustible material (i.e., paper, wood) are desired.
- b. "FS," sulfur trioxide-chlorosulfonic acid solution. This is corrosive to most metals in solution and as smoke and will have damaging action on textiles, including nylon.
- c. "FM," titanium tetrachloride. The smoke is corrosive.

"FS" and "FM" are liquids usually spread and ignited by spray planes.

3.1.3 Signaling Smokes. These smokes are usually made of harmless screening smoke with colored dyes added.

3.1.4 Incendiary Agents. These agents are intended to start fires, destroy equipment or cause casualties by fire. Thermite is used for the destruction of equipment during withdrawals. It is hot enough to fuse a gun tube and breech-block on an artillery piece. Fuel thickeners (napalm), magnesium, fire bombs, fire mines, and plane drop tanks may also be used to set fire to combustible materials. There does not appear to be any practical defense against such chemicals.

3.1.5 Training and Riot-Control Gases. These gases include tear gas and vomiting gases. These apparently have no effect on materials and may be used simply for harassment of enemy troops.

3.1.6 Summary of Chemical Warfare. Chemical warfare agents are intended for use primarily against personnel, except for the incendiaries. Ideally, all

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chemical warfare agents should be completely noncorrosive so that they may be stored in metal containers and delivered in metal bombs or shells without deteriorating the containers during storage or delivery. One of their greatest attributes is that in most cases the agents can disable enemy personnel, if standard gas preventive measures are not followed, without seriously damaging the enemy's equipment, so that this equipment when captured may be turned against the enemy. A perfect chemical-warfare agent, therefore, would be completely harmless to equipment.

Today's chemical warfare agents, however, may inflict some harm to the equipment under attack. Some of the choking agents (phosgene in particular) are corrosive because of the acids they form in the presence of water. Some of the blood poisons would also be corrosive because of the acids formed. These latter types are obsoleted by the "G", "V" and "H" agents. It is highly improbable that they would be used. Neither nerve gases nor blister agents are apparently harmful to materials. These two types are most likely to be used in combat situations because they are most effective and economical.

Of the screening smokes, "WP" will ignite easily flammable materials. "FS" and "FM" are both corrosive. If aerosol-type air filters are used, neither "FS" nor "FM" would enter the interior of the equipment.

The incendiary agents may cause severe damage, but no preventative appears practical.

Training and riot-control gases are apparently harmless to materials.

Decontamination processes which will enable personnel to use the equipment after contamination are, in most cases, harmless to equipment. Rain, sunshine, wind, and the passage of time are the best decontamination agents. GI soap and water, or DANC (decontaminating agent, noncorrosive), are also very good. A slurry of chloride of lime is often used. This would be corrosive in the presence of moisture because of the chlorine released. It should not be left in contact with metals any longer than is absolutely necessary. Also, controlled heat or burning will oxidize the agents, making them harmless. For fire control equipment, gasoline, kerosene and oil may be used to dissolve some contaminants. However, a thin film of contaminate will still remain. Decontaminating with DANC, chloride of lime, or oil is very "messy" and except in extreme emergencies it is doubtful if these decontaminants would be used.

3.2 Biological Warfare

Biological warfare is defined as the dissemination of biological agents (i.e., disease-producing microorganisms, the toxins or poisons released by microorganisms, and the chemical anticrop compounds. Its purpose is to incapacitate the enemy by weakening him through disease, or to

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strike at the source of his food supply by spreading disease among his livestock population or causing failure of his cereal or other food crops. Biological warfare is chiefly a strategic rather than a tactical weapon because of the slow speed with which it affects the enemy due to its dependence in most cases on the propagation of living organisms. It may be used as a powerful psychological weapon against the enemy's home cities.

Sunlight kills the majority of living biological agents, making their dissemination a difficult task. The viruses, rickettsiae, bacteria and protozoa grow only on living substances and so would be harmless to equipment. Fungi will live on materials derived from other plants or animals. The fungi that might be used against personnel are apparently harmless to equipment. There are some molds and mildews which will grow on equipment, given the proper conditions of heat and humidity. These are ordinarily found in tropical climates, and MIL specifications already cover the protection of equipment from them. The toxins released by microorganism, such as those causing botulism and anthrax, are apparently harmless to materiel.

The chemical anticrop compounds include the contact herbicides or weed-killers, the plant-growth regulators, and the defoliants. The contact herbicides would probably not be used because the plant-growth regulators are more potent. The regulators include 2, 4-D and IPC. 2, 4-D is an organic acid, but would be introduced in its solid salt or solid ester form. Neither of these is very soluble, and consequently they would be harmless to materiel. The other plant-growth regulators also appear to be harmless to materiel. The contact herbicides include one or two solid organic acids which would be harmless to materials because of their low concentrations and poor solubility. The defoliants would be more likely to come into contact with fighting equipment than would the weed-killers because they may be used to remove natural cover from front-line areas, making camouflage difficult, whereas the weed killers would be used on the rear areas against the food crops. The defoliants include ammonium thiocyanate and zinc chloride, which are harmless to corrosion-proofed materials.

The biological warfare agents will not corrode metals or short-circuit electrical apparatus. They are therefore completely harmless to the type of equipment under study.

3.3 Radiological Warfare

Radiological warfare is the use in war of materials or methods which result in the release of radioactivity against the enemy. This type of warfare is not limited to an atomic burst, although an atomic burst is the most common means for generating and disseminating radiological agents.

3.3.1 Types of Radiation. There are four types of nuclear radiation: alpha particles, beta particles, gamma rays, and neutrons. Alpha particles present no hazard to materials because of their very poor penetration characteristics. Beta particles have better penetration power but are stopped by such thin material as ordinary cotton fiber clothing, and so are also harmless to materials. Gamma rays are high-energy electromagnetic waves of extremely high

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frequency, which are able to penetrate large thicknesses of material. (One and one-half inches of steel reduces the intensity by only 50%.) These gamma rays are much more harmful to personnel than alpha or beta particles because of their greater penetration ability. Neutrons are particles from atomic nuclei which can penetrate even more material than gamma rays and are more damaging than gamma rays. Neutron radiation, which occurs within the first fraction of a second of a nuclear explosion, is harmful because of the ability of neutrons to make materials surrounding ground zero radioactive.

3.3.2 Damage to Equipment. Large doses of nuclear radiation will affect nearly all materials. Light- and heat- sensitive photographic materials and certain electronic components and plastics, are highly subject to damage. Electronic equipment using transistors also may be seriously damaged by neutron radiation. The only means of producing a neutron flux of damaging magnitude on a battlefield is with a nuclear blast. However, any electronic equipment exposed to a damaging flux of neutrons from a nuclear explosion is likely to be more seriously damaged, or entirely destroyed, by the effects of heat and blast. Massive quantities of gamma radiation are required to produce any damage to materials, except for certain plastics (e.g., teflon and bakelite), which are affected by 10^4 to 10^5 roentgens of gamma radiation. Damage by other phenomena of an atomic explosion is nearly always more significant than damage by radiation.

3.3.3 Damage to Electronic Components. In one test of electronic components under an actual atom-bomb blast (see reference 13, dated August 1957), three groups of components were subjected to up to 92,000 roentgen (r) of gamma radiation. This gamma radiation should be compared with the 5000 r necessary to incapacitate a man immediately, and the smaller amount (450 r) considered to be the median lethal dose (although at this level death is slower).

Various types of electron tubes were investigated for decreased envelope resistance due to radiation effects on glass, and cathode poisoning from radiation. Crystal units were investigated for radiation effects on resonant frequency, "Q" and impedance characteristics. The components were partially shielded from mechanical and thermal effects by 1/16-inch aluminum containers. The crystals were in holders and the electron tubes were in commercial packing material. The resonant frequency and resistance of the crystals and the transconductance, emissivity, envelope resistance and breakdown voltages of the electron tubes were measured before and after the test.

There were no appreciable effects on the electron tubes due to exposure. Two months after the exposure, the electron tubes were examined in the laboratory. Gamma activity was two to three times as great as the normal background level. But there is no health hazard associated with this low level of induced activity, nor is there any interference with the normal functioning of the electron tubes.

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Most of the damage to the quartz crystals was mechanical and could be blamed on the blast. There was a very small change in frequency due to radiation-induced changes in the elastic constants of quartz. The amount of change depended on the cut of the crystal. The test conditions of overpressure, heat and nuclear radiation were felt to be approximately the maximum at which survival of the test components could be expected in use or storage.

3.3.4 Dust Contamination. When an area is contaminated by radioactive dust or other radioactive material, most of the dust or material lies on the outer surfaces of equipment. Without good dust filters, the cooling blowers would suck some of the dust into the interior of the consoles. Filters would prevent the larger particles from entering, and would cut down considerably on the radioactivity available for damage to components. Although radioactive dust may take days to present a hazard to equipment, the level of radioactivity it produces would seriously impair the operator's capabilities within hours unless shielding and a pure air supply were provided. Operator shielding is not feasible because of weight limitations. Air for the operator will be supplied by an M2A1 collective protective filter, and should be pure and harmless.

There are serious problems in manufacturing and storing radioactives which an enemy must overcome before it becomes practical to contaminate an area with radioactive dust without an atomic burst.

3.3.5 Effects of Explosion. There are three primary effects of an atomic or thermonuclear explosion. Blast from an atomic explosion differs from a regular high-explosive blast only in the magnitude of the force and the extent of coverage. Heat from an atomic explosion, like blast, differs only in the magnitude of the heat propagation. The radiation from a nuclear explosion can be divided into two categories: prompt radiation is produced by the explosion within the first 90 seconds; residual radiation is produced by the interaction of radioactive materials with normal constituents of soil, water, etc. This second category may also result from direct application of radioactive materials.

In an atomic burst, intense radioactivity is present for the first few seconds. This radiation, outside of the fireball, is chiefly gamma rays. Neutrons are also released at this time. After the initial burst, gamma activity in materials near ground zero, caused by the interaction of initial neutrons with these materials, creates a problem similar to that created by radioactive dusting. Neutrons have high penetration characteristics and may induce gamma activity within the system, but this activity will be slight compared with that produced by the initial burst and with the amount which would cause serious damage to equipment.

3.3.6 Summary of Radiation Effects. From this discussion it should be clear that radiological warfare presents little danger to equipment, and that its effect is chiefly on operating personnel. A nuclear blast (for the

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purpose of estimating its effects on equipment) may be considered as a tremendously powerful high-explosive blast. Any effect that the released radiation might have on equipment is insignificant at ranges from the blast point where blast and heat effects do not cause considerable damage or complete destruction.

3.4 Summary of Discussion on CBR Warfare

To summarize, some of the older casualty agents (e.g., "CG," "CL," "CK," "AD,") are corrosive or break down into corrosive components. However, these casualty agents have been largely outmoded by the "G" agents, "V" agents, and "H" agents, which are apparently harmless to materials. Some of the smokes are highly corrosive. The incendiary agents definitely present a danger, but this danger must be classed as unavoidable, just as high-explosive blast is. The training and riot-control gases are harmless to material.

In biological warfare, none of the living microorganisms are harmful to materiel except for certain fungi (mildew), against which the equipment is already protected according to MIL specifications. Some of the anticrop compounds are acids or salts in solid form. These are not particularly soluble and would present little hazard to materials.

Radiological warfare and atomic-device damage effects are negligible except to the most susceptible plastics. Blast or heat (to be counted as inevitable in warfare) would cause significantly greater damage. There are at present only limited testing facilities capable of yielding the high neutron dose rates which are necessary to cause possible equipment damage, the Godiva II reactor at Los Alamos being the only one approaching this capability. This reactor could not possibly test an entire system.

Since one of the deciding elements in a CBR attack is surprise, new CBR agents may be introduced from time to time in an attempt to catch the opposition forces off balance. The effects of these agents cannot be predetermined, although it would seem that any new agents would be likely to be closer to the perfect CBR weapon; i.e., one which would disable personnel without harming equipment.

In order to prevent any adverse effects from exposure to an imperfect CBR atmosphere, equipment should be protected. Since the equipment will be in a CBR atmosphere for only relatively short periods of time, painting and anodizing would slow down corrosion until the metals could be freed of the damaging agents, after which new paint or anodizing could be applied. Aerosol filters on the intakes would prevent any harmful liquids, sprays, or dusts from entering the interior of the system, thus protecting the inside chassis. In an atomic blast it would be expected that the paint and other heat-sensitive materials on the outer surfaces would be charred or otherwise damaged (the extent depending on the range from the blast), but no heat damage would be evident in the interior. Blast would not seriously affect the operation of the system until it was strong enough to overturn this item, just as is the case in ordinary high-explosive blasts.

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It appears that a test plan for CBR effects need not be written for the following reasons: If tests were made of the equipment under CBR atmospheres, difficulties might be encountered in recovering the equipment for further tests within a reasonable length of time. The blister agents and nerve gases can be neutralized, but the process is unsatisfactory for delicate parts, involving a slurry of chloride of lime which is about as hard to remove as is the original agent, although it is not as dangerous to personnel. Under chemical attack by the newer chemical agents (which are the agents most likely to be used), no corrosion effects or other harmful effects would be noted on the system. Neither biological-warfare attacks nor radiological attacks would have any effect on the system. Atomic attack would cause damage to the equipment mainly through the effects of blast.

4. (C) CONCLUSIONS

From the above discussion the following may be concluded:

- a. Casualty agents, biological agents and radiological agents are relatively harmless to fire control system materials, as compared with their effects on personnel.
- b. Screening smokes, incendiary agents and atomic-device effects would be equally harmful to both fire control materiel and personnel.
- c. Actual testing of the VIGILANTE fire control system in CBR atmospheres appears at this time to be impractical, considering the extreme difficulties of decontamination and the probability that little new information would be gained.
- d. The use of certain plastics (in particular teflon and bakelite) should be avoided in any equipment that might be subjected to a CBR atmosphere.
- e. If practical, aerosol filters should be used to keep screening smokes and radioactive dust from entering the equipment.
- f. MIL specifications on sand and dust protection, fungus (mildew) resistance, and salt-spray corrosion resistance should be strictly adhered to.
- g. Possible improvement of CBR warfare agent ~~may call~~ for a future re-evaluation of the ~~system~~.

5. (C) RECOMMENDATIONS

It is recommended that:

- a. If it is possible, aerosol filters be placed in all the

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air inlets of the VIGILANTE.

- b. Manufacturers strictly adhere to MIL specifications concerning preventatives against corrosion and fungus damage.
- c. The use of certain plastics (e.g., teflon and bakelite), be avoided if possible when a high radioactivity resistance for the system is desired.
- d. The practicability of testing the VIGILANTE fire control system for CBR warfare effects be reviewed after a period of six months to a year.

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